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(54) LOW DENSITY MICROSPHERES AND THEIR USE AS CONTRAST AGENTS FOR COMPUTED TOMOGRAPHY

MIKROSPHÄREN GERINGER DICHT E UND IHRE VERWENDUNG ALS KONTRASTMITTEL IN
DER COMPUTERTOMOGRAFIE

MICROSPHERES DE FAIBLE DENSITE ET LEUR UTILISATION COMME AGENTS DE
CONTRASTE EN SCANOGRAPHIE

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(73) Proprietor: **IMARX PHARMACEUTICAL CORP.**
Tucson, AZ 85719 (US)

(72) Inventor: **Unger, Evan C.**
Tucson, AZ 85749 (US)

(74) Representative: **Hallybone, Huw George et al**
CARPMAELS AND RANSFORD
43 Bloomsbury Square
London WC1A 2RA (GB)

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Description

BACKGROUND OF THE INVENTION

[0001] Computed tomography (CT) is a widespread diagnostic imaging method which measures, in its imaging process, the radiodensity (electron density) of matter. This radiodensity is depicted using CT in terms of Hounsfield Units (HU). Hounsfield Units, named after the inventor of the first CT scanner, reflect the relative absorption of CT X-rays by matter, the absorption being directly proportional to the electron density of that matter. Water, for example, has a value of 0 HU, air a value of - 1000 HU, and dense cortical bone a value of + 1000 HU. Because of the similarity in density of various tissues in the body, however, contrast agents have been sought to change the relative density of different tissues, and improve the overall diagnostic efficacy of this imaging method.

[0002] In the search for contrast agents for CT, researchers have generally sought to develop agents that will increase electron density in certain areas of a region of the body (positive contrast agents). Barium and iodine compounds, for example, have been developed for this purpose. For the gastrointestinal tract, barium sulfate is used extensively to increase the radiodensity of the bowel lumen on CT scans. Iodinated water soluble contrast media are also used to increase density within the gastrointestinal tract, but are not used as commonly as the barium compounds, primarily because the iodine preparations are more expensive than barium and prove less effective in increasing radiodensity within this region of the body.

[0003] Despite their widespread use, however, barium and iodine compounds are suboptimally effective as gastrointestinal contrast agents for CT. For example, if the concentration is too low, there is little contrast. Conversely, if the concentration is too high, then these radiodense contrast agents cause beam hardening artifacts which are seen as streaks on the CT images. It is also difficult to visualize the bowel mucosa with either the barium or iodine contrast agents.

[0004] In an attempt to improve upon the efficacy of contrast agents for the gastrointestinal tract, lipid emulsions that are capable of decreasing electron density (negative contrast agents) have been developed. Because lipids have a lower electron density than water, lipids provide a negative density on CT (a negative HU value). While these lipid emulsions appear to be more effective than the barium and iodine agents at improving visualization of the mucosa of the bowel, these contrast agents have limitations. First, there is a limitation to the concentration of lipid which a patient can tolerably drink, which puts a limit on the change in density (or HU) which the lipid based CT contrast agent can provide. Lipid emulsions are also frequently expensive.

Furthermore, these lipid formulations are generally perishable, which provides for packaging and storage prob-

lems.

[0005] New and/or better contrast agents for computed tomography imaging are needed. The present invention is directed toward this important end.

[0006] EP-A-0327490 describes ultrasonic contrast agents comprising microparticles containing gases and/or fluids with a boiling point below 60°C in free or bonded form. The particles are formed from amylose or a synthetic biodegradable polymer that dissolves or degrades in the human body. Particularly preferred biodegradable polymers are amyloses and cyclodextrins, since these polymers are soluble in water and form inclusion compounds with gaseous molecules. In use, the microparticles dissolve in the body to release the gas trapped therein as microbubbles that provide good ultrasonic contrast.

[0007] EP-A-0052575 describes microbubble precursors for use as ultrasonic contrast agents. The precursors are particulate solids consisting predominantly of particles which have a plurality of gas-filled voids communicating with the surface of the particles and a plurality of nuclei for bubble formation. As the particles dissolve in the body, they release microbubbles that function as ultrasonic contrast agents.

[0008] The present invention provides a method of providing an image of the gastrointestinal region or other body cavities of a patient comprising: (a) administering to the patient a contrast medium which comprises a substantially homogenous aqueous suspension of low density microspheres having an internal void volume of at least 75% of the total volume of the microsphere; and (b) scanning the patient using computed tomography imaging to obtain visible images of the gastrointestinal region or other body cavities.

[0009] The present invention also provides a method of providing an image of the gastrointestinal region or other body cavities of a patient comprising: (a) administering to the patient a contrast medium which comprises an aqueous suspension of a biocompatible polymer, a perfluorocarbon gas, and a thickening or suspending agent, wherein in said suspension said biocompatible polymer associates with said perfluorocarbon gas to form one or more gas-filled microspheres; and (b) scanning the patient using computed tomography imaging to obtain visible images of the gastrointestinal region or other body cavities.

[0010] The present invention also provides a method of providing an image of a region of a patient comprising: (a) administering to the patient a contrast medium which comprises a substantially homogenous aqueous suspension of low density microspheres having an internal void volume of at least 75% of the total volume of the microsphere; and (b) scanning the patient using diagnostic imaging to obtain visible images of the region of the patient.

[0011] The present invention further provides a method of providing an image of a region of a patient comprising: (a) administering to the patient a contrast medi-

um which comprises an aqueous suspension of a biocompatible polymer, a perfluorocarbon gas, and a thickening or suspending agent, wherein in said suspension said biocompatible polymer associates with said perfluorocarbon gas to form one or more gas-filled microspheres; and (b) scanning the patient using diagnostic imaging to obtain visible images of the region of the patient.

[0012] A wide variety of different low density microspheres may be utilized in the present invention. Preferably, the microspheres (which are small spheres having a central void or cavity), are composed of biocompatible synthetic polymers or copolymers prepared from monomers such as acrylic acid, methacrylic acid, ethyleneimine, crotonic acid, acrylamide, ethyl acrylate, methyl methacrylate, 2-hydroxyethyl methacrylate (HEMA), lactic acid, glycolic acid, E-caprolactone, acrolein, cyanoacrylate, bisphenol A, epichlorohydrin, hydroxyalkylacrylates, siloxane, dimethylsiloxane, ethylene oxide, ethylene glycol, hydroxyalkyl-methacrylates, N-substituted acrylamides, N-substituted methacrylamides, N-vinyl-2-pyrrolidone, 2,4-pentadiene-1-ol, vinyl acetate, acrylonitrile, styrene, p-amino-styrene, p-amino-benzyl-styrene, sodium styrene sulfonate, sodium 2-sulfoxyethylmethacrylate, vinyl pyridine, aminoethyl methacrylates, 2-methacryloyloxy-trimethylammonium chloride, and polyvinylidene, as well polyfunctional crosslinking monomers such as N,N'-methylenebisacrylamide, ethylene glycol dimethacrylates, 2,2'-(p-phenylenedioxy)-diethyl dimethacrylate, divinylbenzene, triallylamine and methylenebis-(4-phenyl-isocyanate), including combinations thereof. Preferable polymers include polyacrylic acid, polyethyleneimine, polymethacrylic acid, polymethylmethacrylate, polysiloxane, polydimethylsiloxane, polylactic acid, poly(ϵ -caprolactone), epoxy resin, poly(ethylene oxide), poly(ethylene glycol), and polyamide (nylon). Preferable copolymers include the following: polyvinylidene-polyacrylonitrile, polyvinylidene-polyacrylonitrile-polymethylmethacrylate, and polystyrene-polyacrylonitrile. A most preferred copolymer is polyvinylidene-polyacrylonitrile. The term biocompatible, as used herein in conjunction with the terms monomer or polymer, is employed in its conventional sense, that is, to denote polymers that do not substantially interact with the tissues, fluids and other components of the body in a adverse fashion in the particular application of interest, such as the aforementioned monomers and polymers. Other suitable biocompatible monomers and polymers will be readily apparent to those skilled in the art, once armed with the present disclosure.

[0013] The microspheres used in the methods of the present invention are low density. By low density, it is meant that the microspheres of the invention have an internal void (cavity) volume which is at least 75 % of the total volume of the microsphere. Preferably, the microspheres have a void volume of at least 80 %, more preferably at least 85 %, even more preferably at least

90 %, of the total volume of the microspheres.

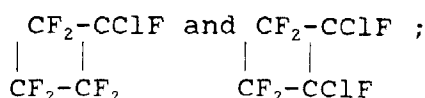
[0014] The microspheres may be of varying size, provided they are low density. Suitable size microspheres include those ranging from between 1 and 1000 microns in outside diameter, preferably between 5 and 70 microns in outside diameter. Most preferably, the microspheres are about 50 microns in outside diameter.

[0015] The microspheres used in the methods of the invention may be prepared by various processes, as will be readily apparent to those skilled in the art, once armed with the present disclosure, such as by interfacial polymerization, phase separation and coacervation, multiorifice centrifugal preparation, and solvent evaporation. Suitable procedures which may be employed or modified in accordance with the present disclosure to prepare microspheres within the scope of the invention include those procedures disclosed in Garner et al., U.S. Patent No. 4,179,546, Garner, U.S. Patent No. 3,945,956, Cohrs et al., U.S. Patent No. 4,108,806, Japan Kokai Tokkyo Koho 62 286534, British Patent No. 1,044,680, Kenaga et al., U.S. Patent No. 3,293,114, Morehouse et al., U.S. Patent No. 3,401,475, Walters, U.S. Patent No. 3,479,811, Walters et al., U.S. Patent No. 3,488,714, Morehouse et al., U.S. Patent No. 3,615,972, Baker et al., U.S. Patent No. 4,549,892, Sands et al., U.S. Patent No. 4,540,629, Sands et al., U.S. Patent No. 4,421,562, Sands, U.S. Patent No. 4,420,442, Mathiowitz et al., U.S. Patent No. 4,898,734, Lencki et al., U.S. Patent No. 4,822,534, Herbig et al., U.S. Patent No. 3,732,172, Himmel et al., U.S. Patent No. 3,594,326, Sommerville et al., U.S. Patent No. 3,015,128, Deasy, *Microencapsulation and Related Drug Processes*, Vol. 20, Chs. 9 and 10, pp. 195-240 (Marcel Dekker, Inc., N.Y., 1984), Chang et al., *Canadian J. of Physiology and Pharmacology*, Vol 44, pp. 115-129 (1966), and Chang, *Science*, Vol. 146, pp. 524-525 (1964).

[0016] In accordance with the preferable synthesis protocol, the microspheres are prepared using a heat expansion process such as is described in Garner et al., U.S. Patent No. 4,179,546, Garner, U.S. Patent No. 3,945,956, Cohrs et al., U.S. Patent No. 4,108,806, British Patent No. 1,044,680, and Japan Kokai Tokkyo Koho 62 286534. In general terms, the heat expansion process is carried out by preparing microspheres of an expandable polymer or copolymer which contain in their void (cavity) a volatile liquid. The microsphere is then heated, plasticising the microsphere and volatilizing the gas, causing the microsphere to expand to up to about several times its original size. When the heat is removed, the thermoplastic polymer retains at least some of its expanded shape. Microspheres produced by this process tend to be of particularly low density, and are thus preferred. The foregoing described process is well known in the art, and is referred to herein as the heat expansion process for preparing low density microspheres.

[0017] Polymers useful in the heat expansion process will be readily apparent to those skilled in the art and include thermoplastic polymers or copolymers, including polymers or copolymers of many of the monomers described above. Preferable of the polymers and copolymers described above include the following copolymers: polyvinylidene-polyacrylonitrile, polyvinylidene-polyacrylonitrile-polymethylmethacrylate, and polystyrene-polyacrylonitrile. A most preferred copolymer is polyvinylidene-polyacrylonitrile.

[0018] Volatile liquids useful in the heat expansion process will also be well known to those skilled in the art and include: aliphatic hydrocarbons such as ethane, ethylene, propane, propene, butane, isobutane, neopentane, acetylene, hexane, heptane; chlorofluorocarbons such as CCl_3F , CCl_2F_2 , CClF_3 , $\text{CClF}_2\text{-CCl}_2\text{F}_2$,



tetraalkyl silanes such as tetramethyl silane, trimethyl-ethyl silane, trimethylisopropyl silane, and trimethyl n-propyl silane; as well as perfluorocarbons such as those having between 1 and 9 carbon atoms and between 4 and 20 fluorine atoms, especially C_4F_{10} . In general, it is important that the volatile liquid not be a solvent for the microsphere polymer or copolymer. The volatile liquid should also have a boiling point that is below the softening point of the microsphere polymer or co-polymer. Boiling points of various volatile liquids and softening points of various polymers and copolymers will be readily ascertainable to one skilled in the art, and suitable combinations of polymers or copolymers and volatile liquids will be easily apparent to the skilled artisan. By way of guidance, and as one skilled in the art would recognize, generally as the length of the carbon chain of the volatile liquid increases, the boiling point of that liquid increases. Also, by mildly preheating the microspheres in water in the presence of hydrogen peroxide prior to definitive heating and expansion may pre-soften the microsphere to allow expansion to occur more readily.

[0019] For example, to produce suitable microspheres, vinylidene and acrylonitrile may be copolymerized in a medium of isobutane liquid using one or more of the foregoing modified or unmodified literature procedures, such that isobutane becomes entrapped within the microspheres. When such microspheres are then heated to between 80°C and 120°C , the isobutane gas expands, which in turn expands the microspheres. After heat is removed, the expanded polyvinylidene and acrylonitrile copolymer microspheres remain substantially fixed in their expanded position. The resulting low density microspheres are extremely stable both dry and suspended in an aqueous media. Isobutane is utilized merely as an illustrative liquid, with the understanding

that other liquids which undergo liquid/gas transitions at temperatures useful for the synthesis of these microspheres and formation of the very low density microspheres upon heating can be substituted for isobutane. Similarly, monomers other than vinylidene and acrylonitrile may be employed in preparing the microsphere.

[0020] Most preferably, the low density microspheres employed are those commercially available from Expancel, Nobel Industries, Sundsvall, Sweden, such as the EXPANCEL 551 DE™ microspheres. The EXPANCEL 551 DE™ microspheres are composed of a copolymer of vinylidene and acrylonitrile which have encapsulated therein isobutane liquid. Such microspheres are sold as a dry composition and are approximately 50 microns in size. The EXPANCEL 551 DE™ microspheres have a specific gravity of only 0.02 to 0.05, which is between one-fiftieth and one-twentieth the density of water.

[0021] In one embodiment, the microspheres used in the present invention are gas-filled. By gas-filled, it is meant that at least part of the void volume inside the microspheres is occupied by the gas. Preferably, substantially all of the void volume inside the microspheres is occupied by the gas. The gas may be any type of gas, such as, for example, carbon dioxide, oxygen, nitrogen, xenon, argon, neon, helium and air. Preferably, the gas is carbon dioxide, oxygen, nitrogen, xenon, argon, neon and helium. Most preferably, the gas is inert, that is, a gas that is substantially resistant to chemical or physical action. The gas-filled low density microspheres may be synthesized under pressure such that gases are solubilized in the liquid employed in microsphere synthesis. When the pressure is removed, the gas comes out of solution to fill the microsphere void. Such microspheres can further be subjected to a heat expansion process, as described above.

[0022] For example, to produce the gas-filled microspheres, one may copolymerize vinylidene and acrylonitrile using one or more of the foregoing procedures, such as phase separation/coacervation techniques in a pressurized and/or low temperature environment (e.g., at about (300 psi), 2.1 MPa and/or at about 0°C) with a high concentration of dissolved gas (e.g., dissolved nitrogen) in solution, to form a large microsphere containing the dissolved gas. When the pressure is removed and/or the temperature raised, the gas bubbles come out of solution, forming gas filled microspheres. Such microspheres can further be subjected to a heat expansion process, as described above.

[0023] It is preferable that the microspheres be relatively stable in the gastrointestinal tract or other body cavities during the length of time necessary for completing an imaging examination. Low density microspheres prepared from the aforementioned monomer and polymer compositions will provide such stable microspheres.

[0024] In order for these microspheres to serve as effective CT contrast agents, it is necessary for the micro-

spheres to be mixed in solution in a substantially homogeneous suspension. This can be accomplished by using thickening and suspending agents. A wide variety of thickening and suspending agents may be used to prepare the substantially homogeneous suspensions of the microspheres. Suitable thickening and suspending agents, for example, include any and all biocompatible agents known in the art to act as thickening and suspending agents. Particularly useful are the natural thickening and suspending agents alginates, xanthan gum, guar, pectin, tragacanth, bassorin, karaya, gum arabic, casein, gelatin, cellulose, sodium carboxymethylcellulose, methylcellulose, methylhydroxycellulose, bentonite, colloidal silicic acid, and carrageenin, and the synthetic thickening and suspending agents polyethylene glycol, polypropylene glycol, and polyvinylpyrrolidone. As those skilled in the art would recognize, once armed with the present disclosure, the suspending agents may be formulated, if desired, to be either less dense than water or of neutral density, so as to not subtract from the density lowering capabilities of the microspheres. For example, a cellulose suspension may have a somewhat lower density than water, e.g., a 2 weight % cellulose solution with 0.25 weight % xanthan gum has a density of 0.95. The thickening and suspending agents may be employed in varying amounts, as those skilled in the art would recognize, but preferably are employed in amounts of 0.25 to 10 weight % preferably 0.5 to 5 weight % of the contrast medium.

[0025] The substantially homogeneous, aqueous suspension of low density microspheres used in the methods of the invention are useful as CT contrast agents. These agents are capable of producing negative contrast in the gastrointestinal tract or in other body cavities, providing effective contrast enhancement and improved visualization in these areas of the body. The phrase gastrointestinal region or gastrointestinal tract, as used herein, includes the region of a patient defined by the esophagus, stomach, small and large intestines, and rectum. The phrase other body cavities, as used herein, includes any region of the patient, other than the gastrointestinal region, having an open passage, either directly or indirectly, to the external environment, such regions including the sinus tracts, the fallopian tubes, the bladder, etc. The patient can be any type of mammal, but most preferably is a human. As one skilled in the art would recognize, administration of the contrast medium to the patient may be carried out in various fashions, such as orally, rectally, or by injection. When the region to be scanned is the gastrointestinal region, administration of the contrast medium of the invention is preferably carried out orally or rectally. When other body cavities such as the fallopian tubes or sinus tracts are to be scanned, administration is preferably by injection. As would also be recognized by one skilled in the art, wide variations in the amounts of the gas filled microspheres can be employed in the methods and kits of the invention, with the precise amounts varying depending upon

such factors as the mode of administration (e.g., oral, rectal, by injection), and the specific body cavity and portion thereof for which an image is sought (e.g., the stomach of the gastrointestinal tract). Typically, dosage is initiated at lower levels and increased until the desired contrast enhancement is achieved.

[0026] For CT imaging, it is generally desirable to decrease the density of the lumen of the gastrointestinal tract or other body cavities to at least about -30 HU, the maximum decrease being limited by the practical amount of the microspheres which may be suspended in the aqueous media and ingested by the patient. In general, a decrease in HU to between -30 HU and -150 HU is sufficient to mark the inside of the bowel or other body cavity. By way of general guidance, and as a rough rule of thumb, to decrease the density of the microsphere aqueous suspension to about -150 HU, the microspheres must occupy about 15 % of the total volume of the aqueous suspension. To achieve a density of about -50 HU, the microspheres must occupy about 5 % of the total volume of the solution. The volume of contrast agent administered to the patient is typically between 50 to 1000 cc. Using the EXPANCEL 551 DE™ microspheres as a model, it has been found that about 0.6 grams of the dry 50 micron spheres in 100 cc of aqueous suspension is sufficient to decrease the density of the suspension to nearly -150 HU.

[0027] It should be noted that smaller microspheres are generally more stable in suspension, but usually have higher specific gravity than larger microspheres. Therefore, for CT, the size and particular microspheres, as well as the suspending media (thickening and suspending agents) should be selected to minimize specific gravity, while maximizing the stability of the suspension.

[0028] The contrast medium utilized of the present invention may also be employed with other conventional additives suitable for use in the applications contemplated for the subject invention.

[0029] Where gastrointestinal applications are concerned, such additives include conventional biocompatible anti-gas agents, osmolality raising agents, gastrointestinal transit agents (the latter agents serving to decrease the gastrointestinal transit time and increase the rate of gastrointestinal emptying) and, in some instances, gas-forming agents.

[0030] As used herein the term anti-gas agent is a compound that serves to minimize or decrease gas formation, dispersion and/or adsorption. A number of such agents are available, including antacids, antiflatulents, antifoaming agents, and surfactants. Such antacids and antiflatulents include, for example, activated charcoal, aluminum carbonate, aluminum hydroxide, aluminum phosphate, calcium carbonate, dihydroxyaluminum sodium carbonate, magaldrate magnesium oxide, magnesium trisilicate, simethicone, sodium carbonate, loperamide hydrochloride, diphenoxylate, hydrochloride with atropine sulfate, Kaopectate™ (kaolin) and bismuth salts. Suitable antifoaming agents useful as anti-gas

agents include simethicone, protected simethicone, siloxalkylene polymers, siloxane glycol polymers, polyoxypropylene-polyoxyethylene copolymers, polyoxyalkylene amines and imines, branched polyamines, mixed oxyalkylated alcohols, finely divided silica either alone or mixed with dimethyl polysiloxane, sucroglycamides (celynols), polyoxylalkylated natural oils, halogenated silicon-containing cyclic acetals, lauryl sulfates, 2-lactylic acid esters of unicarboxylic acids, triglyceride oils. Particles of polyvinyl chloride or silica may also function as anti-foaming agents in the subject invention. Suitable surfactants include perfluorocarbon surfactants, such as, for example, DuPont Zonyl™ perfluoroalkyl surfactants known as Zonyl™ RP or Zonyl™ NF, available from DuPont, Chemicals and Pigments Division, Jackson Laboratory, Deepwater, NJ 08023. Of course, as those skilled in the art will recognize, any anti-gas agents employed must be suitable for use within the particular biological system of the patient in which it is to be used. The concentration of such anti-gas agents may vary widely, as desired, as will be readily apparent to those skilled in the art. Typically, however, such agents are employed in concentrations of between 20 and 2000 ppm, most preferably in concentrations between 50 and 1000 ppm.

[0031] Suitable osmolality raising agents include polyols and sugars, for example, mannitol, sorbitol, arabitol, xylitol, glucose, sucrose, dextrose, and saccharine, with mannitol and sorbitol being most preferred. The concentration of such osmolality raising agents may vary, as desired, however, generally a range of 5 to 70 g/l, preferably 30 to 50 g/l of the contrast medium. Such compounds may also serve as sweeteners for the ultimate formulation, if desired.

[0032] Gastrointestinal transit agents include algin, as well as many of the compounds listed above as thickening and suspending agents, with algin being most preferred. The amount of such agents will, of course, vary as those skilled in the art will recognize, but generally will be employed in an amount of between 5 and 40 mmol/l.

[0033] In some applications, it may be helpful to incorporate gas-forming agents into the contrast medium. Gas-forming agents include sodium bicarbonate, calcium carbonate, aminomalonate, and the like, which will form gas, for example, upon introduction into the gastrointestinal tract. Such gas-forming agents will serve to distend the gastrointestinal tract and create a form of "double contrast" between the gas and the low density microspheres.

[0034] Kits useful for computed tomography imaging of the gastrointestinal region or other body cavities in accordance with the present invention comprise low density microspheres, and a thickening or suspending agent, in addition to conventional computed tomography imaging kit components. Such conventional computed tomography kit components will be readily apparent to those skilled in the art, once armed with the

present disclosure.

[0035] Where imaging of the gastrointestinal region is contemplated, such computed tomography kit components may include, for example, anti-gas agents, osmolality raising agents, gastrointestinal transit agents and, in some instances, gas-forming agents.

[0036] The computed tomography imaging principles and techniques which are employed are conventional and are described, for example, in *Computed Body Tomography*, Lee, J.K.T., Sagel, S.S., and Stanley, R.J., eds., Ch. 1, pp. 1-7 (Raven Press, NY 1933). Any of the various types of computed tomography imaging devices can be used in the practice of the invention, the particular type or model of the device not being critical to the method of the invention.

[0037] The preparation of microspheres and contrast media for use in the methods of the present invention is further described in the following Examples. Examples 1-7 are prophetic examples based at least in part on the teachings of Garner, U.S. Patent No. 3,945,956, and describe the preparation of microspheres by a heat expansion process. Examples 8-9 are actual examples that describe the preparation of contrast media for use in the methods of the invention. The following Examples are not to be construed as limiting the scope of the appended Claims.

Examples

Example 1

[0038] A vessel is filled with 50 parts by weight of deionized water and 6 parts by weight of a 25 percent by weight aqueous colloidal silica dispersion. A mixture of 0.3 parts by weight of a 10 weight percent solution of diethylamine-adipic acid copolymer is added to the above. A condensation reaction occurs creating a mixture having a viscosity of about 95 centipoise at a temperature of about 27° C. Potassium dichromate (0.05 parts by weight) is added to the aqueous phase as a water phase polymerization inhibitor. Sodium chloride (1 part by weight) is also present in the water phase; hydrochloric acid is used to adjust the pH of the aqueous phase to 4.0. Styrene (15 parts by weight), acrylonitrile (10 parts by weight), a mixture of diethylbenzene and divinylbenzene (0.21 parts by weight comprising a 55:45 percent mixture of each respectively), 6.25 parts by weight of isobutane and 0.07 parts by weight of secondary butyl peroxydicarbonate. The oil phase is added to the water phase with violent agitation created by a shearing blade rotating at 10,000 RPM employing a mixing blender. After the material has reacted for about 30 minutes, the mixture is poured into a citrate bottle and capped. The material is maintained at about 50°C in the citrate bath for about 24 hours and agitated throughout this time. At the end of 24 hours, the reaction bottle is cooled and the material is removed, washed and dried. A portion of the microspheres are set aside and the re-

mainder are heated in an air oven for a period of about 30 minutes at about 150°C. A sample of the dry unexpanded and dry expanded microspheres are then studied by a Coulter Counter. The dry unexpanded microspheres have a size of about 2 to 12 microns. About half of the microspheres exposed to the heating process show expansion.

Example 2

[0039] The procedures of Example 1 are substantially repeated with the exception that 1 part by weight of methanol is added to the reaction mixture. The dry unexpanded and dry heat expanded microspheres are then studied by Coulter Counter. The dry unexpanded microspheres measure about 8 to 10 microns in size. Essentially all the microspheres exposed to heat expand.

Example 3

[0040] The procedures of Example 2 are substantially repeated except that after synthesis of the microspheres, a slurry of the microspheres is added to an aqueous solution containing 35 weight percent hydrogen peroxide. This slurry is heated to a temperature of about 50°C for about 3.5 hours and subsequently cooled and air-dried. A portion of the microspheres is then added to water and heated to a temperature of about 75°C with vigorous stirring for about 30 seconds. Study with Coulter Counter shows that pretreatment with hydrogen peroxide enables a lower temperature and briefer period of heating to be used for definitive heating and expansion.

Example 4

[0041] The procedures of Example 1 are substantially repeated with the exception that 5 parts by weight of ethanol are included in the reaction mixture forming the microspheres. Coulter Counter shows that the dry unexpanded particles have diameters of about 24 to 28 microns. When heated, essentially all of the microspheres expand.

Example 5

[0042] The procedures of Example 1 are substantially repeated with the exception that in place of methanol, 1 part by weight of normal butanol is used. The diameter of the dry unexpanded microspheres is about 10 to 12 microns and on heating, essentially all of the microspheres expand.

Example 6

[0043] The procedures of Example 1 are substantially repeated with the exception that the volatile liquid isobu-

tane is replaced with perfluorocarbon liquid (C₄F₁₀). The remainder of the process is similar. The resulting microspheres are filled with perfluorocarbon liquid rather than isobutane.

Example 7

[0044] The procedures of Example 1 are substantially repeated with the exception that the reaction is conducted in a pressurized vessel enabling pressurization with gas and simultaneous agitation (agitation accomplished with either sonication or shearing blades within the device). As the microspheres are formed within the device, the vessel is pressurized to about 2.1 MPa (300 psi) with nitrogen gas. The vessel is then depressurized, allowing the gas to come out of solution. The microspheres are then subjected to heat as substantially described in Example 1.

Example 8

[0045] A suspension of 2 % of 22 micron fiber length cellulose in 0.25 % xanthan gum in water was prepared. Scans by CT showed a CT density of about -45 HU for the cellulose suspension. EXPANCEL 551 DE™ polyvinylidene-polyacrylonitrile microspheres, 50 microns in size, were then suspended in the aqueous cellulose suspension at a concentration of 0.4 grams of microspheres per 100 ml of cellulose suspension using vigorous shaking. The resulting suspension remained substantially homogeneous for about 10 minutes. The suspension was again shaken vigorously to render it substantially homogeneous and scanned immediately by CT. The resulting CT density as measured by the scanner was about -96 HU.

Example 9

[0046] A suspension of 1 % algin was prepared. EXPANCEL 551 DE™ microspheres were added to the algin suspension in an amount of about 0.2 grams of microspheres per deciliter of algin suspension, using vigorous shaking, to form a substantially homogeneous suspension. The resulting suspension was found to have much greater stability than the cellulose/microsphere suspension of Example 1. The algin/microsphere suspension was then scanned by CT, with the density as measured by the scanner being about -40 HU.

[0047] Various modifications of the invention within the scope of the appended Claims, in addition to those shown and described herein, will be apparent to those skilled in the art from the foregoing description.

Claims

1. A method of providing an image of the gastrointestinal-

tinal region or other body cavities of a patient comprising:

- (a) administering to the patient a contrast medium which comprises a substantially homogeneous aqueous suspension of low density microspheres having an internal void volume of at least 75% of the total volume of the microsphere; and
- (b) scanning the patient using computed tomography imaging to obtain visible images of the gastrointestinal region or other body cavities.

2. A method according to claim 1 wherein said microspheres are gas-filled.

3. A method according to claim 2 wherein said gas is selected from the group consisting of carbon dioxide, oxygen, nitrogen, xenon, argon, neon and helium.

4. A method according to claim 2, wherein said gas is air.

5. A method according to claim 2 wherein said gas comprises a perfluorocarbon.

6. A method of providing an image of the gastrointestinal region or other body cavities of a patient comprising:

- (a) administering to the patient a contrast medium which comprises an aqueous suspension of a biocompatible polymer, a perfluorocarbon gas, and a thickening or suspending agent, wherein in said suspension said biocompatible polymer associates with said perfluorocarbon gas to form one or more gas-filled microspheres; and
- (b) scanning the patient using computed tomography imaging to obtain visible images of the gastrointestinal region or other body cavities.

7. A method of providing an image of a region of a patient comprising:

- (a) administering to the patient a contrast medium which comprises a substantially homogeneous aqueous suspension of low density microspheres having an internal void volume of at least 75% of the total volume of the microsphere; and
- (b) scanning the patient using diagnostic imaging to obtain visible images of the region of the patient.

8. A method according to claim 7 wherein said microspheres are gas-filled.

9. A method according to claim 8 wherein said gas is selected from the group consisting of carbon dioxide, oxygen, nitrogen, xenon, argon, neon and helium.

10. A method according to claim 8, wherein said gas is air.

11. A method according to claim 8 wherein said gas comprises a perfluorocarbon.

12. A method of providing an image of a region of a patient comprising:

- (a) administering to the patient a contrast medium which comprises an aqueous suspension of a biocompatible polymer, a perfluorocarbon gas, and a thickening or suspending agent, wherein in said suspension said biocompatible polymer associates with said perfluorocarbon gas to form one or more gas-filled microspheres; and
- (b) scanning the patient using diagnostic imaging to obtain visible images of the region of the patient.

13. A method according to any preceding claim, wherein said microspheres are composed of biocompatible synthetic polymers or copolymers.

14. A method according to claim 13, wherein said polymers or copolymers are prepared from monomers that include a polyfunctional crosslinking monomer.

15. A method according to any preceding claim wherein said microspheres comprise synthetic polymers or copolymers prepared from the group of monomers consisting of acrylic acid, methacrylic acid, ethyleneimine, crotonic acid, acrylamide, ethyl acrylate, methyl methacrylate, 2-hydroxyethyl methacrylate, lactic acid, glycolic acid, ϵ -caprolactone, acrolein, cyanoacrylate, bisphenol A, epichlorhydrin, hydroxyalkylacrylates, siloxane, dimethylsiloxane, ethylene oxide, ethylene glycol, hydroxyalkyl-methacrylates, N-substituted acrylamides, N-substituted methacrylamides, N-vinyl-2-pyrrolidone, 2,4-pentadiene-1-ol, vinyl acetate, acrylonitrile, styrene, p-amino-styrene, p-amino-benzyl-styrene, sodium styrene sulfonate, sodium 2-sulfoxyethyl methacrylate, vinyl pyridine, aminoethyl methacrylates, 2-methacryloyloxy-trimethylammonium chloride, N, N'-methylenebisacrylamide, ethylene glycol dimethacrylates, 2,2'-(p-phenylenedioxy)-diethyl dimethacrylate, divinylbenzene, triallylamine, and methylenebis-(4-phenyl-isocyanate).

16. A method according to claim 15 wherein said microspheres comprise synthetic polymers or copoly-

- mers prepared from the group of monomers consisting of acrylic acid, methacrylic acid, ethyleneimine, crotonic acid, acrylamide, ethyl acrylate, methyl methacrylate, 2-hydroxyethyl methacrylate, lactic acid, glycolic acid, ϵ -caprolactone, acrolein, cyanoacrylate, bisphenol A, epichlorhydrin, hydroxyalkylacrylates, siloxane, dimethylsiloxane, ethylene oxide, ethylene glycol, hydroxyalkyl-methacrylates, N-substituted acrylamides, N-substituted methacrylamides, N-vinyl-2-pyrrolidone, 2,4-pentadiene-1-ol, vinyl acetate, acrylonitrile, styrene, p-amino-styrene, p-amino-benzyl-styrene, sodium styrene sulfonate, sodium 2-sulfoxyethylmethacrylate, vinyl pyridine, aminoethyl methacrylates, and 2-methacryloyloxytrimethyl-ammonium chloride.
17. A method according to any of claims 1 to 13 wherein said microspheres comprise synthetic polymers or copolymers selected from the group consisting of polyacrylic acid, polyethyleneimine, polymethacrylic acid, polymethylmethacrylate, polysiloxane, polydimethylsiloxane, polylactic acid, poly(ϵ -caprolactone), epoxy resin, poly(ethylene oxide), poly(ethylene glycol), polyamide, polyvinylidene-polyacrylonitrile, polyvinylidene-polyacrylonitrile-polymethylmethacrylate, and polystyrene-polyacrylonitrile.
 18. A method according to claim 17 wherein said microspheres comprise polyvinylidene-polyacrylonitrile copolymer.
 19. A method according to any one of claims 1 to 13 wherein said microspheres comprise a polyoxypropylene-polyoxyethylene copolymer.
 20. A method according to any preceding claim wherein said microspheres are gas-filled microspheres, and said gas comprises a perfluorocarbon selected from the group consisting of perfluorocarbons having between 1 and 9 carbon atoms and between 4 and 20 fluorine atoms.
 21. A method according to claim 20 wherein said perfluorocarbon gas is selected from the group consisting of perfluorocarbons having 1 to 4 carbon atoms and 4 to 10 fluorine atoms.
 22. A method according to claim 20 wherein said perfluorocarbon gas is selected from the group consisting of perfluorocarbons having 4 to 9 carbon atoms and 10 to 20 fluorine atoms.
 23. A method according to claim 22 wherein said perfluorocarbon gas is C_4F_{10} .
 24. A method according to claim 1 or 7 wherein said microspheres are prepared by a heat expansion process.
 25. A method according to claim 1 or 7 wherein said contrast medium further comprises a thickening or suspending agent.
 26. A method according to claim 6, 12 or 25 wherein said thickening or suspending agent is selected from the group consisting of alginates, xanthan gum, guar, pectin, tragacanth, bassorin, karaya, gum arabic, casein, gelatin, cellulose, sodium carboxymethylcellulose, methylcellulose, methylhydroxycellulose, bentonite, colloidal silicic acid, carrageenin, polyethylene glycol, polypropylene glycol, and polyvinylpyrrolidone.
 27. A method according to claim 26 wherein said thickening or suspending agent is selected from the group consisting of cellulose, sodium carboxymethylcellulose, methylcellulose and methylhydroxycellulose.
 28. A method according to claim 27 wherein said thickening or suspending agent is methylcellulose.
 29. A method according to any preceding claim wherein the contrast medium further comprises a compound selected from the group consisting of antacids, antiflatulents, antifoaming agents and surfactants.
 30. A method according to claim 29 wherein said compound which is selected from the group consisting of antacids, antiflatulents, antifoaming agents and surfactants comprises dimethylpolysiloxane.
 31. A method according to claim 30 wherein said dimethylpolysiloxane is simethicone.

Patentansprüche

1. Methode zur Lieferung eines Bilds der gastrointestinalen Region oder anderer Körperhöhlen eines Patienten, die folgendes umfaßt:
 - a) Verabreichung eines Kontrastmittels an den Patienten, das eine weitgehend homogene wäßrige Suspension von Mikrosphären mit geringer Dichte beinhaltet, die ein inneres Hohlraumvolumen von mindestens 75 % des Gesamtvolumens der Mikrosphäre besitzen, und
 - b) Scannen des Patienten mit computertomografischer Bildsynthese zur Erzeugung sichtbarer Abbildungen der gastrointestinalen Region oder anderer Körperhöhlen.
2. Methode gemäß Anspruch 1, wobei die Mikrosphären mit Gas gefüllt sind.

3. Methode gemäß Anspruch 2, wobei dieses Gas ausgewählt ist aus der Gruppe bestehend aus Kohlendioxid, Sauerstoff, Stickstoff, Xenon, Argon, Neon und Helium. 5
4. Methode gemäß Anspruch 2, wobei dieses Gas Luft ist. 10
5. Methode gemäß Anspruch 2, wobei dieses Gas einen Perfluorkohlenstoff enthält. 15
6. Methode zur Lieferung eines Bilds der gastrointestinalen Region oder anderer Körperhöhlen eines Patienten, die folgendes umfaßt: 20
 - a) Verabreichung eines Kontrastmittels an den Patienten, das eine wäßrige Suspension eines biokompatiblen (körperverträglichen) Polymers, ein Perfluorkohlenstoffgas und ein Verdickungs- oder Suspensionsmittel enthält, wobei sich in dieser Suspension das biokompatible Polymer mit dem Perfluorkohlenstoffgas assoziiert, so daß eine oder mehrere gasgefüllte Mikrosphären entstehen; 25
 - b) Scannen des Patienten mit computertomografischer Bildsynthese zur Erzeugung sichtbarer Abbildungen der gastrointestinalen Region oder anderer Körperhöhlen. 30
7. Methode zur Lieferung eines Bilds einer Körperregion eines Patienten, die folgendes umfaßt: 35
 - a) Verabreichung eines Kontrastmittels an den Patienten, das eine weitgehend homogene wäßrige Suspension von Mikrosphären mit geringer Dichte beinhaltet, die ein inneres Hohlraumvolumen von mindestens 75 % des Gesamtvolumens der Mikrosphäre besitzen, und 40
 - b) Scannen des Patienten mit diagnostischer Bildsynthese zur Erzeugung sichtbarer Abbildungen der Körperregion des Patienten. 45
8. Methode gemäß Anspruch 7, wobei die Mikrosphären mit Gas gefüllt sind. 50
9. Methode gemäß Anspruch 8, wobei dieses Gas ausgewählt ist aus der Gruppe bestehend aus Kohlendioxid, Sauerstoff, Stickstoff, Xenon, Argon, Neon und Helium. 55
10. Methode gemäß Anspruch 8, wobei dieses Gas Luft ist. 60
11. Methode gemäß Anspruch 8, wobei dieses Gas einen Perfluorkohlenstoff enthält. 65
12. Methode zur Lieferung eines Bilds einer Körperregion eines Patienten, die folgendes umfaßt: 70
 - a) Verabreichung eines Kontrastmittels an den Patienten, das eine wäßrige Suspension eines biokompatiblen Polymers, ein Perfluorkohlenstoffgas und ein Verdickungs- oder Suspensionsmittel enthält, wobei sich in dieser Suspension das biokompatible Polymer mit dem Perfluorkohlenstoffgas assoziiert, so daß eine oder mehrere gasgefüllte Mikrosphären entstehen; 75
 - b) Scannen des Patienten mit diagnostischer Bildsynthese zur Erzeugung sichtbarer Abbildungen der Körperregion des Patienten. 80
13. Methode gemäß dem vorstehenden Anspruch, wobei die Mikrosphären aus biokompatiblen synthetischen Polymeren oder Copolymeren bestehen. 85
14. Methode gemäß Anspruch 13, wobei diese Polymere oder Copolymere aus Monomeren hergestellt sind, zu denen auch ein polyfunktionelles Vernetzungsmonomer gehört. 90
15. Methode gemäß einem der vorstehenden Ansprüche, wobei die Mikrosphären aus synthetischen Polymeren oder Copolymeren bestehen, die hergestellt sind aus der Gruppe von Monomeren bestehend aus Acrylsäure, Methacrylsäure, Ethylenimin, Crotonsäure, Acrylamid, Ethylacrylat, Methylmethacrylat, 2-Hydroxyethylmethacrylat, Milchsäure, Glycolsäure, ε-Caprolacton, Acrolein, Cyanoacrylat, Bisphenol A, Epichlorhydrin, Hydroxyalkylacrylaten, Siloxan, Dimethylsiloxan, Ethylenoxid, Ethylenglycol, Hydroxyalkylmethacrylat, N-substituierten Acrylamiden, N-substituierten Methacrylamiden, N-vinyl-2-pyrrolidon, 2,4-Pentadien-1-ol, Vinylacetat, Acrylnitril, Styrol, p-Aminostyrol, p-Aminobenzylstyrol, Natriumstyrolsulfonat, Natrium-2-sulfoxyethylmethacrylat, Vinylpyridin, Aminoethylmethacrylaten, 2-Methacryloyloxytrimethylammoniumchlorid, N,N'-Methylenbisacrylamid, Ethylenglycoldimethacrylaten, 2,2'-(p-Phenylendioxy)-diethylmethacrylat, Divinylbenzol, Triallylamin und Methylenbis-(4-phenylisocyanat). 95
16. Methode gemäß Anspruch 15, wobei die Mikrosphären synthetische Polymeren oder Copolymeren umfassen, die hergestellt sind aus der Gruppe von Monomeren bestehend aus Acrylsäure, Methacrylsäure, Ethylenimin, Crotonsäure, Acrylamid, Ethylacrylat, Methylmethacrylat, 2-Hydroxyethylmethacrylat, Milchsäure, Glycolsäure, ε-Caprolacton, Acrolein, Cyanoacrylat, Bisphenol A, Epichlorhydrin, Hydroxyalkylacrylaten, Siloxan, Dimethylsiloxan, Ethylenoxid, Ethylenglycol, Hydroxyalkylmethacrylat, N-substituierten Acrylamiden, N-substitu-

- ierten Methacrylamiden, N-vinyl-2-pyrrolidon, 2,4-Pentadien-1-ol, Vinylacetat, Acrylnitril, Styrol, p-Aminostyrol, p-Aminobenzylstyrol, Natriumstyrolsulfonat, Natrium-2-sulfoxyethylmethacrylat, Vinylpyridin, Aminoethylmethacrylaten, 2-Methacryloyloxytrimethylammoniumchlorid.
- 5
17. Methode gemäß einem der Ansprüche 1 bis 13, wobei die Mikrosphären synthetische Polymeren oder Copolymeren umfassen, die ausgewählt sind aus der Gruppe bestehend aus Polyacrylsäure, Polyethylenimin, Polymethacrylsäure, Polymethylmethacrylat, Polysiloxan, Polydimethylsiloxan, Polymilchsäure, Poly(ϵ -Caprolacton), Epoxidharz, Polyethylenoxid, Polyethylenglycol, Polyamid, Polyvinyliden-Polyacrylnitril, Polyvinyliden-Polyacrylnitril-Polymethylmethacrylat und Polystyrol-Polyacrylnitril.
- 10
18. Methode gemäß Anspruch 17, wobei die Mikrosphären ein Polyvinyliden-Polyacrylnitril-Polymer umfassen.
- 15
19. Methode gemäß einem der Ansprüche 1 bis 13, wobei die Mikrosphären ein Polyoxypolypropylen-Polyoxyethylen-Copolymer umfassen.
- 20
20. Methode gemäß einem der vorstehenden Ansprüche, wobei die Mikrosphären gasgefüllt sind und das Gas einen Perfluorkohlenstoff enthält, der ausgewählt ist aus der Gruppe bestehend aus Perfluorkohlenstoffen mit 1 bis 9 Kohlenstoffatomen und 4 bis 20 Fluoratomen.
- 25
21. Methode gemäß Anspruch 20, wobei das Perfluorkohlenstoffgas ausgewählt ist aus der Gruppe bestehend aus Perfluorkohlenstoffen mit 1 bis 4 Kohlenstoffatomen und 4 bis 10 Fluoratomen.
- 30
22. Methode gemäß Anspruch 20, wobei das Perfluorkohlenstoffgas ausgewählt ist aus der Gruppe bestehend aus Perfluorkohlenstoffen mit 4 bis 9 Kohlenstoffatomen und 10 bis 20 Fluoratomen.
- 35
23. Methode gemäß Anspruch 22, wobei das Perfluorkohlenstoffgas C_4F_{10} ist.
- 40
24. Methode gemäß Anspruch 1 oder 7, wobei die Mikrosphären durch einen Wärmeausdehnungsprozeß hergestellt werden.
- 45
25. Methode gemäß Anspruch 1 oder 7, wobei das Kontrastmittel zusätzlich ein Verdickungs- oder Suspensionsmittel enthält.
- 50
26. Methode gemäß den Ansprüchen 6, 12 oder 25, wobei das Verdickungs- oder Suspensionsmittel ausgewählt ist aus der Gruppe bestehend aus Alginaten, Xanthanlösung, Guar, Pektin, Tragant, Basso-
- 55
27. Methode gemäß Anspruch 26, wobei das Verdickungs- oder Suspensionsmittel ausgewählt ist aus der Gruppe bestehend aus Cellulose, Natriumcarboxymethylcellulose, Methylcellulose und Methylhydroxycellulose.
28. Methode gemäß Anspruch 27, wobei das Verdickungs- oder Suspensionsmittel Methylcellulose ist.
29. Methode gemäß einem der vorstehenden Ansprüche, wobei das Kontrastmittel zusätzlich eine Verbindung enthält, die ausgewählt ist aus der Gruppe bestehend aus Antazida, entblähenden Mitteln, Entschäumungsmitteln und grenzflächenaktiven Substanzen.
30. Methode gemäß Anspruch 29, wobei die Verbindung, die ausgewählt ist aus der Gruppe bestehend aus Antazida, entblähenden Mitteln, Entschäumungsmitteln und grenzflächenaktiven Substanzen, Dimethylpolysiloxan umfaßt.
31. Methode gemäß Anspruch 30, wobei es sich bei dem Dimethylpolysiloxan um Simethicon handelt.

Revendications

1. Méthode de mise à disposition d'une image de la région gastro-intestinale ou d'autres cavités du corps d'un patient comprenant:
- (a) le fait d'administrer au patient un agent de contraste contenant une suspension aqueuse essentiellement homogène de microsphères de faible densité présentant un volume poreux interne de 75 % minimum du volume total de la microsphère; et
- (b) le fait de scanner le patient au moyen d'un scanographe afin d'obtenir des images visibles de la région gastro-intestinale ou d'autres cavités du corps.
2. Méthode selon la revendication 1, dans laquelle les dites microsphères sont remplies de gaz.
3. Méthode selon la revendication 2, dans laquelle ledit gaz est sélectionné parmi le groupe constitué du dioxyde de carbone, de l'oxygène, de l'azote, du xénon, de l'argon, du néon et de l'hélium.

4. Méthode selon la revendication 2, dans laquelle ledit gaz est l'air.
5. Méthode selon la revendication 2, dans laquelle ledit gaz comprend un perfluorocarbone. 5
6. Méthode de mise à disposition d'une image de la région gastro-intestinale ou d'autres cavités du corps d'un patient comprenant: 10
 - (a) le fait d'administrer au patient un agent de contraste contenant une suspension aqueuse d'un polymère biocompatible, un gaz perfluorocarbure, et un agent épaississant ou suspensif, ledit polymère biocompatible étant associé dans ladite suspension avec ledit gaz perfluorocarbure pour former une ou plusieurs microsphères remplies de gaz; et
 - (b) le fait de scanner le patient au moyen d'un scanographe afin d'obtenir des images visibles de la région gastro-intestinale ou d'autres cavités du corps. 15
7. Méthode de mise à disposition d'une image d'une région d'un patient comprenant: 20
 - (a) le fait d'administrer au patient un agent de contraste contenant une suspension aqueuse essentiellement homogène de microsphères de faible densité présentant un volume poreux interne de 75 % minimum du volume total de la microsphère; et
 - (b) le fait de scanner le patient au moyen d'un scanographe afin d'obtenir des images visibles de la région du patient. 25
8. Méthode selon la revendication 7, dans laquelle lesdites microsphères sont remplies de gaz.
9. Méthode selon la revendication 8, dans laquelle ledit gaz est sélectionné parmi le groupe constitué du dioxyde de carbone, de l'oxygène, de l'azote, du xénon, de l'argon, du néon et de l'hélium. 30
10. Méthode selon la revendication 8, dans laquelle ledit gaz est l'air. 35
11. Méthode selon la revendication 8, dans laquelle ledit gaz comprend un perfluorocarbure. 40
12. Méthode de mise à disposition d'une image d'une région d'un patient comprenant: 45
 - (a) le fait d'administrer au patient un agent de contraste comprenant une suspension aqueuse d'un polymère biocompatible, un gaz perfluorocarbure, et un agent épaississant ou suspensif, ledit polymère biocompatible étant associé dans ladite suspension avec ledit gaz perfluorocarbure pour former une ou plusieurs microsphères remplies de gaz; et
 - (b) le fait de scanner le patient au moyen d'un scanographe afin d'obtenir des images visibles de la région du patient. 50
13. Méthode selon l'une des revendications susmentionnées, dans laquelle lesdites microsphères sont composées de polymères ou copolymères synthétiques biocompatibles. 55
14. Méthode selon la revendication 13, dans laquelle lesdits polymères ou copolymères sont préparés à partir de monomères incluant un monomère réticulant polyfonctionnel.
15. Méthode selon l'une des revendications susmentionnées, dans laquelle lesdites microsphères comprennent des polymères ou copolymères synthétiques préparés à partir du groupe de monomères constitué par l'acide acrylique, l'acide méthacrylique, l'imine d'éthylène, l'acide crotonique, l'acrylamide, l'acrylate d'éthyle, le méthacrylate de méthyle, le méthacrylate de 2-hydroxy-éthyle, l'acide lactique, l'acide glycolique, l'ε-caprolactone, l'acroléine, le cyanoacrylate, le bisphénol A, l'épichlorhydrine, les hydroxyalkyl-acrylates, le siloxane, le diméthylsiloxane, l'oxyde d'éthylène, l'éthylène glycol, les hydroxyalkyl-méthacrylates, les acrylamides substitués en position N, les méthacrylamides substitués en position N, le N-vinyl-2-pyrrolidone, le 2,4-pentadiène-1-ol, l'acétate de vinyle, l'acrylonitrile, le styrène, le p-amino-styrène, le p-aminobenzyl-styrène, le sodium-styrène-sulfonate, le méthacrylate de sodium-2-sulfoxyéthyle, la pyridine de vinyle, les méthacrylates d'aminoéthyle, le chlorure de 2-méthacryloyloxytriméthylammonium, le N,N'-méthylènebisacrylamide, les diméthacrylates d'éthylène glycol, le diméthacrylate de 2,2'-(p-phénylènedioxy)diéthyle, le divinylbenzène, le triallylamine et le méthylènebis-(4-phénylisocyanate).
16. Méthode selon la revendication 15, dans laquelle lesdites microsphères comprennent des polymères ou copolymères synthétiques préparés à partir du groupe de monomères constitué par l'acide acrylique, l'acide méthacrylique, l'imine d'éthylène, l'acide crotonique, l'acrylamide, l'acrylate d'éthyle, le méthacrylate de méthyle, le méthacrylate de 2-hydroxy-éthyle, l'acide lactique, l'acide glycolique, l'ε-caprolactone, l'acroléine, le cyanoacrylate, le bisphénol A, l'épichlorhydrine, les hydroxyalkyl-acrylates, le siloxane, le diméthylsiloxane, l'oxyde d'éthylène, l'éthylène glycol, les hydroxyalkyl-méthacrylates, les acrylamides substitués en position N, les méthacrylamides substitués en position N, le N-vinyl-2-pyrrolidone, le 2,4-pentadiène-1-ol, l'acétate

- de vinyle, l'acrylonitrile, le styrène, le p-amino-styrène, le p-amino-benzyl-styrène, le sodium-styrènesulfonate, le sodium-2-sulfoxyéthyle-méthacrylate, la pyridine de vinyle, les méthacrylates d'aminoéthyle et le chlorure de 2-méthacryloyloxy-triméthylammonium.
17. Méthode selon l'une des revendications 1 à 13, dans laquelle lesdites microsphères comprennent des polymères ou copolymères synthétiques sélectionnés parmi le groupe constitué de l'acide polyacrylique, de l'imine de polyéthylène, de l'acide polyméthacrylique, du méthacrylate de polyméthyle, du polysiloxane, du polydiméthyl-siloxane, de l'acide polylactique, du poly(ϵ -caprolactone), de la résine époxy, du poly(oxyde d'éthylène), du poly(glycol d'éthylène), du polyamide, du polyvinylidène-polyacrylonitrile, du polyvinylidène-polyacrylonitrile-polyméthylméthacrylate et du polystyrène-polyacrylonitrile.
18. Méthode selon la revendication 17, dans laquelle lesdites microsphères comprennent un copolymère de polyvinylidène-polyacrylonitrile.
19. Méthode selon l'une des revendications 1 à 13, dans laquelle lesdites microsphères comprennent un copolymère de polyoxypropylène-polyoxyéthylène.
20. Méthode selon l'une des revendications susmentionnées, dans laquelle lesdites microsphères sont des microsphères remplies de gaz et dans laquelle ledit gaz contient un perfluorocarbène sélectionné parmi le groupe constitué de perfluorocarbones possédant entre 1 et 9 atomes de carbone et entre 4 et 20 atomes de fluor.
21. Méthode selon la revendication 20, dans laquelle ledit gaz perfluorocarbène est sélectionné parmi le groupe constitué de perfluorocarbones possédant 1 à 4 atomes de carbone et 4 à 10 atomes de fluor.
22. Méthode selon la revendication 20, dans laquelle ledit gaz perfluorocarbène est sélectionné parmi le groupe constitué de perfluorocarbones possédant 4 à 9 atomes de carbone et 10 à 20 atomes de fluor.
23. Méthode selon la revendication 22, dans laquelle ledit gaz perfluorocarbène est le C_4F_{10} .
24. Méthode selon la revendication 1 ou 7, dans laquelle lesdites microsphères sont obtenues par un procédé d'expansion thermique.
25. Méthode selon la revendication 1 ou 7, dans laquelle ledit agent de contraste contient également un agent épaississant ou suspensif.
26. Méthode selon la revendication 6, 12 ou 25, dans laquelle ledit agent épaississant ou suspensif est sélectionné parmi le groupe constitué d'alginate, de la gomme xanthan, du guar, de la pectine, de l'adragante, de la bassorine, de la gomme de sterculia, de la gomme arabique, de la caséine, de la gélatine, de la cellulose, de la carboxyméthylcellulose de sodium, de la méthylcellulose, de la méthylhydroxycellulose, de la bentonite, de l'acide silicique colloïdal, de la carraghénine, du polyéthylène-glycol, du polypropylène-glycol et du polyvinylpyrrolidone.
27. Méthode selon la revendication 26, dans laquelle ledit agent épaississant ou suspensif est sélectionné parmi le groupe constitué de la cellulose, de la carboxyméthylcellulose de sodium, de la méthylcellulose et de la méthylhydroxycellulose.
28. Méthode selon la revendication 27, dans laquelle ledit agent épaississant ou suspensif est la méthylcellulose.
29. Méthode selon l'une des revendications susmentionnées, dans laquelle l'agent contrastant comprend également un composant sélectionné parmi le groupe constitué d'antacides, d'antiflatulents, d'agents antimousse et de surfactants.
30. Méthode selon la revendication 29, dans laquelle ledit composant, sélectionné parmi le groupe constitué d'antacides, d'antiflatulents, d'agents antimousse et de surfactants, comprend le diméthylpolysiloxane.
31. Méthode selon la revendication 30, dans laquelle ledit diméthylpolysiloxane est le siméthicone.